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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

SPECIAL RESEARCH NUMBER.

This number contains the account of the Annual Meeting of The Illuminating Engineering Society on May 9th, including the ***Report*** of the ***Committee on Research.***

Also the paper on "***The Sphere of the Scientific and Technical Press in relation to Technical Education and Industrial Research,*** read by Dr. W. Garnett at a meeting of the *Circle of Scientific, Technical, and Trade Journalists,* on March 14th, 1916.

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EDITORIAL.

Research in Illuminating Engineering.

On pages 167–177 we give an account of the proceedings at the Annual Meeting of the Illuminating Engineering Society on May 9th, at which the usual Report of the Council was presented. In spite of the inevitable and growing difficulties arising through the war, the Society has fortunately been able to carry on its work with undiminished activity. Meetings have again been devoted to subjects of special interest at the present time, and, in several cases, have been useful in eliciting fruitful suggestions for further work. Some of these suggestions are crystallised in the Report presented by the special Research Committee.

It will be recalled that this Committee was announced shortly before the outbreak of war, but it was found at that time impracticable to proceed with the investigations. But at the present time there appears to be an opportunity for useful work, especially in view of the growing appreciation of the value of industrial research and the various steps that are now being taken for the organisation of scientific investigation. As previously mentioned, one of the most important steps taken in this connection has

been the formation of the Committee of the Privy Council for the Organisation of Scientific and Industrial Research, and we are glad to note, from several bulletins that have been issued, that a considerable amount of useful work has already been initiated.

Accordingly the Illuminating Engineering Society, in common with many other scientific and technical institutions, has been considering how the efforts of its members can best be applied in experimental work, and the first result is the Report which appears on pp. 172–177 in this number. The Report is concluded by an elaborate list of subjects for investigation. It was thought desirable to make this list as complete as possible, with a view to showing how wide is the ground to be covered, and how many are the opportunities for experiments which may be followed up in the future. Naturally there are many matters that will have to be postponed at the present moment, and it is proposed to concentrate on several researches, such as the investigation of illuminating glassware, which calls for immediate effort. While it may truly be said that the difficulties of initiating such researches are accentuated by the large number of members absent in the Forces or on special war-work, there can be no question that these matters deserve immediate attention, and should not be relegated to the period after the war. We hope, however, that the assistance of members will be freely offered, in spite of the pressing demands on their time, and that the problems involved will be considerably simplified by the co-operation of other societies. In some cases in which a considerable amount of experimenting will require to be done, adequate financial support will be required, but in view of the direct industrial importance of the matters to be considered it will doubtless be forthcoming.

While referring to this matter, we should also like to draw attention to one other point in the Annual Report,—the need for increased membership in order to carry on satisfactorily the work in hand. With such a programme as the Report on Research before them, members cannot fail to appreciate the usefulness of the movement. It is hoped, therefore, that they will do all in their power to assist by inducing friends to join and swell the existing membership.

It is also to be hoped that gas and electrical supply companies and other institutions which derive direct benefit from the work of the Society, will see their way to giving substantial support to its endeavours.

Technical Education and Industrial Research.

In a recent issue we gave a brief account of the proceeding at the meeting of the Circle of Scientific, Technical, and Trade Journalists on March 14th, at which a paper on " The Sphere of the Scientific and Technical Press in Relation to Technical Education and Industrial Research " was read by Dr. Wm. Garnett. In this issue we are reproducing Dr. Garnett's instructive paper *in extenso* (see pp. 153—166), and in the next number we hope to deal with the discussion at this and the subsequent meeting on May 16th.

The proceedings at this meeting were supplementary to those at the previous meeting of the Circle. An account of some of the recent proposals for the organisation of scientific work and the improvement of technical education was presented, and Mr. Gerald Lightfoot, who attended in the unavoidable absence of Mr. Hughes, the Prime Minister of Australia, gave

an account of the comprehensive scheme for the establishment of a National Institute of Science and Industry in Australia—a matter which was also dealt with by the Right Hon. Andrew Fisher in his speech at the Annual Meeting of the British Science Guild on the 17th inst. Among others who took part in the discussion may be mentioned the Right Hon. Arthur Dyke Acland, Sir John Cockburn, and Professor R. A. Gregory.

During the past few months the constant attention given to the subject of scientific and industrial research by various committees and institutions has been an encouraging sign, but it has become apparent that in order that these suggestions may crystallise into a coherent national scheme, a serious effort to promote the interchange of views, and to bring about co-operation between these various bodies will have to be made. A feature of the scheme explained by Mr. Lightfoot was the provision for a Bureau of Information to enable the constant exchange of information to take place and prevent overlapping of work, and the whole principle of the scheme is based upon co-operation and the subordination of various bodies to a central authoritative Council. In Australia the problem is doubtless simplified to some extent by the fact there are few existing important scientific bodies to be considered, and therefore the framework can be built up on a logical basis. In this country co-operation can only be brought about more slowly, and one of the most effective means of influencing public opinion in this direction is undoubtedly judicious discussion in the press. We take the opportunity to reproduce the following resolution, proposed by Dr. Wm. Garnett, seconded by Mr. E. J. P. Benn, and carried unanimously at the meeting of the Circle, which effectively crystallises its aims in this matter:—

That this Meeting urges upon the various Associations, Institutions, and Committees engaged in the consideration of Technical Education and Industrial Research the necessity for co-operating in order to present a National Scheme for the consideration of the Government.

That in any measures taken for the preparation and execution of such a National Scheme the co-operation of the Scientific and Technical Press should be secured.

That this meeting is of opinion that the Press should use its influence to encourage the Teaching of Science in Schools and Colleges of all grades, and to determine the proper position of science in Civil Service and other examinations, especially with reference to the influence of these examinations upon Education.

That in the meantime it is desirable that all possible support should be given by the Press and the Public to the work of the Advisory Council to the Committee of the Privy Council for the Organisation and Development of Scientific and Industrial Research, and that Industrial Associations should report to the Advisory Council on the facilities required for the conduct of Research in connection with their particular industries.

Sir Corbet Woodall.

During the past year several leading gas engineers have passed away. But a few weeks ago, at the Annual Meeting of the Illuminating Engineering Society, the Chairman referred in feeling terms to the loss of two valued Vice-Presidents, Mr. Edward Allen and Professor Vivian Lewes.

We have now to record with deep regret the death of Sir Corbet Woodall, a distinguished Honorary Life Member of the Society, who passed away on May 17th.

On page 180 there appears an appreciation of Sir Corbet Woodall from the pen of Mr. F. W. Goodenough, his friend and associate for many years. There is no need for us to enlarge upon his distinguished professional career, nor to recall the many professional honours and distinctions he received. But we would like to add our tribute to the gifts of intellect and personality which kindled the respect and admiration of all who knew Sir Corbet Woodall.

In the year 1912—1913 Sir Corbet Woodall occupied the Presidential Chair of the Institution of Gas Engineers, the Society of British Gas Industries, and the British Commercial Gas Association—a unique testimony to his rare combination of technical and administrative abilities. His high sense of duty prevented him from accepting positions unless he saw his way clear to render constant personal service, and his many duties at this period would doubtless have taxed the energies of a much younger man.

Sir Corbet was intimately associated with many advances in gas lighting which have profoundly influenced illumination in this country.

Yet, while continually encouraging technical advances in the manufacture and use of gas, he never failed to emphasise the human side—to insist that those engaged in the supply of gas were carrying out an important public service, and should do all in their power to earn the confidence of the consumer and the goodwill of the general public. His influence in this direction was manifested in the creation of the Sales Department of the Gas Light and Coke Co., and in the wise and far-sighted policy that have marked the educational campaign of the British Commercial Gas Association. In all things he was an enthusiast for co-operation, and his name will always be associated with the adoption of the great Co-partnership Scheme by the Gas Light and Coke Co. during his term of office.

Although his life was devoted to the service of the gas industry, Sir Corbet Woodall took a large-minded and enlightened view of other illuminants. No better example of his policy in this respect could be mentioned than the statesmanlike conception of the National Gas Congress and Exhibition, held at Shepherd's Bush in 1913. In presiding at the Inaugural Banquet he struck the note that was followed consistently throughout the Congress, when he said :—

"I need hardly say that this is not an anti-electric, it is a pro-gas exhibition. We recognise that there is room and a place for both gas and electricity in the service of the community. We use electricity for certain purposes in our own works; the electrician uses gas largely in his works for the making of cables, dynamos and lamps, while the consumer in many cases uses gas to produce electricity. The presence of so many among us to-day, who are at the head of both gas and electricity undertakings, is evidence of community of interests between the two."

In the death of Sir Corbet Woodall the gas industry loses a gifted engineer and a wise administrator, the Nation a great and representative Englishman, whose work will be remembered for many years to come.

LEON GASTER.

THE SPHERE OF THE SCIENTIFIC AND TECHNICAL PRESS IN RELATION TO TECHNICAL EDUCATION AND INDUSTRIAL RESEARCH.

AT a meeting of the Scientific and Technical Circle of the Institute of Journalists, held in the Hall of the Institute of Journalists on Tuesday, March 14th, a discussion took place on "The Sphere of the Scientific and Technical Press in Relation to Technical Education and Industrial Research." Mr. L. Gaster, Chairman of the Circle presided.

In opening the proceedings the Chairman said :—

"To-night I have the pleasure of introducing to you two gentlemen who have made a special study of the subjects of Technical Education and Industrial Research, Dr. W. Garnett, late Educational Adviser to the London Council, and Mr. A. P. M. Fleming, who is associated with the Industrial Research Dept., of the British Westinghouse Co. Dr. Garnett, who has made a life-long study of the subject, surveys the whole question of the organisation of education from the broad industrial aspect. Mr. Fleming will tell us something of the development of industrial research in the United States and elsewhere, and discuss the application of these facts to industries in this country.

"To us, as scientific and technical journalists falls the duty of studying these questions and ascertaining as far as possible, how we can help in spreading a knowledge of the benefits of applied science and bringing about a better appreciation of the value of education in relation to our industrial life.

"It is common knowledge that the war has led us to examine our present position, and has showed that in many directions we do not yet possess the complete educational facilities which the scientific development of our industries demands. Industries depending on scientific principles cannot be built up suddenly, and steady persistent effort will be needed. Above all action in this respect must be preceded by deliberation and discussion. In the present disturbed condition of trade it is, perhaps, hardly possible to embark on any wide scheme of practical development, but, if we are to be ready when the war is over we must utilise the present period to marshall our resources, to enlist the support of all those who can do something to prepare for the future. In particular, a great deal can be done to prepare public opinion for what is coming, and to create a favourable atmosphere for the reception of definite proposals.

"It is here that the technical and scientific press can help. It may be necessary to create new educational centres and improved sources of scientific research. But the most immediate need is clearly to organise those resources which we already possess. The various learned and scientific societies throughout the country are already doing good work and our educational institutions and colleges are also considering these problems. But it is, perhaps, not sufficiently recognised that in the scientific and technical press there is available a most valuable channel for education, and a unique means of reaching manufacturers throughout the country. The technical journals throughout the country can each prepare the way in their respective trades and industries, but in order to do so they must themselves understand the practical possibilities of industrial research, and must be kept in touch with the progress in their respective fields.

"One thing I am confident the war has taught us; the need for better co-ordination of the efforts of scientific workers. We must consider how to link together the activities of all the various scientific societies, educational institutions and scientific and technical journals, and it may be that in the future we shall see some form of co-ordination of all these activities so that we may all be members of an army of workers in applied science, engaged in the development of our national industries."

The Chairman then called upon Dr. Garnett to read his paper (see pp. 154-166).

THE SPHERE OF THE SCIENTIFIC AND TECHNICAL PRESS IN RELATION TO TECHNICAL EDUCATION AND RESEARCH.

By DR. WILLIAM GARNETT

(late Educational Adviser to the London County Council).

(Introduction to a discussion at a meeting of the Circle of Scientific, Technical and Trade Journalists held at the Hall of the Institute of Journalists, Tudor Street, Blackfriars, London, E.C., at 8 p.m. on Tuesday, March 14th, 1916.)

1. The Technical Instruction Acts and the Education Acts.

ON May 1st, 1904, the day appointed under the Education (London) Act, 1903, the last trace of technical education was removed from the Statute Book of England. Although the Education Act of 1902 had come into operation in the provinces a year earlier, London remained under the Technical Instruction Acts, with their definitions of technical and manual instruction, and technical education to cover both, until "the appointed day," but since then we have had no statutory definition of technical education. In fact, there is not, and never has been, any statutory definition of education itself. We must regard it as a primary conception, like time and space, which everybody is supposed to understand but no one can define in terms of things simpler than itself. The repeal of these definitions, with all the restrictions they implied, greatly increased the powers of local education authorities, for it was no longer illegal to supply, or aid the supply of, instruction in the practice of any trade, industry or employment; a restriction introduced into the Technical Instruction Act by the Labour Party in 1889, which they themselves regretted when experience had given them confidence in the educational work done by the local authorities. Unfortunately, in London at any rate, it was not possible in 1904 to take full advantages of the freedom which the new Act offered in the direction of rendering further assistance to professional and trade education, because the transfer to the Council of the whole of the work of the School Board diverted attention to the administration and development of elementary education and the training and selection of teachers, with the organisation of secondary education as a means thereto; and technical education, for which the law now prescribed no exceptional treatment, had to experience a temporary check and bide its time for further rapid development.

2. Technical Education since 1904.

I do not mean that nothing has been done during the last twelve years for the benefit of industry,and especially scientific industry. The Imperial College would itself be sufficient answer to such a suggestion. Many trade schools have been established for women and some pre-apprenticeship schools of an essentially trade character have been provided for boys, while maintenance scholarships have been made tenable in both classes of schools; but we have not yet established systematic courses of training on carefully thought-out lines for the industrial statesman or leader of industry, the technical expert, the works manager, the workshop manager, the foreman, the precision worker or other highly skilled mechanic, including the superintendent of automatic or semi-automatic tools, and the machine minder. The war has taught us the need of an industrial army organised with its due proportion of officers, non-commissioned officers and men, all trained for the work they have

to do. One great difficulty with which the Ministry of Munitions has had to cope has been the lack of precision workers, men who could work in hardened steel to an accuracy of one three-thousandth of an inch or less, and hereafter our engineering schools will have to adapt themselves to the requirements of the most up-to-date works.

3. Need for Practical Work in Schools.

But of far more importance than any technical detail is the development throughout our whole educational system of individual resourcefulness and self-reliance. These qualities are not produced by studying text-books, often written by authors who themselves have no first-hand knowledge of their subject, or by listening to oral teaching and reproducing it in an essay. Even the solution of mathematical problems, while it quickens a very useful type of intelligence, does not necessarily develop resourcefulness or self-reliance except on paper. Our educational system must aim at bringing children more into contact with *things*, from which the symbolic methods of the drawing office and the mathematical class-room, which are absolutely essential in their place, should naturally grow, as the young worker finds by experience that he needs their assistance. The Scout problem of lighting a fire in the open air with the use of not more than two matches develops more self-reliance than the mastery of all the facts in a text-book of geography or history. I am not depreciating these latter subjects; I am only seeking for an illustration by comparison. I have often said that of the subjects I studied at school, Latin prose has, perhaps, been to me the most useful, not because I am ever called upon to write a Latin epigram, but because the practice of Latin prose developed the habit of examining carefully into the meaning of words and the best forms of expression, and much of my life has been spent among papers and Acts of Parliament, though my tastes would have led me into work of construction. Closely associated with self-reliance and resourcefulness is quickness of perception which is also developed by good scout training, but necessitates dealing with real things.

4. How Can the Press Help.

The first step which I think should be taken by the scientific and technical press to help the education of the country is to create a public opinion in favour of further developing in elementary and secondary schools the self-reliance and resourcefulness which spring from a conscious mastery of Nature through the successful performance of real pieces of work, and not their paper analogues. As things now are, self-reliance is learned mainly in the playing fields; but much progress has been made in the last few years in the desired direction in the elementary schools. This is a reform which will affect the whole population. The next step is to endeavour to secure more systematic training for each of the classes of workers to which I have referred, and in particular to see that industrial statesmen study economics not less diligently than workshop appliances.

In order that the teaching of the schools should be more closely related to the practical problems of life it is essential that some of the teachers, whose tastes lie in that direction, should have greater opportunities than they at present enjoy of becoming acquainted with trade processes, not with a view to their becoming tradesmen, but in order that they may secure the interest of their pupils in questions bearing on trade work, and be in a position to point out the practical value of the school instruction in arithmetic, geometry, mechanics and elementary science. Elsewhere I have suggested that the two years' training college course should, in some cases, be supplemented by a third year in a polytechnic or other technical institute where trade classes are held; so that the student, while working in the science laboratories, may have the opportunity of seeing practical work in a number of trades, and, perhaps, gaining a little experimental experience in some of them.

Moreover, apart from their indirect influence on the methods of teaching in elementary and secondary schools, scientific and technical journals can themselves act as a valuable educational agency by the dissemination of informa-

tion and ideas on applied science and technical research in the industries with which they are in contact.

5. National Organisation of Industry.

In the February number of a trade journal, the *Watchmaker and Jeweler*, the Editor, Mr. W. A. Steward, remarks, after referring to the aerial struggle of the nations in "Locksley Hall":—

"It is not the poet who warns you now, but the business man, awakened from his lethargy and dreams of security. The trade war is to become something more than securing personal aggrandisement, it is to be waged as a matter of national strength, as a means of preventing another great war. Let our trade battalions find a leader who will organise them into army corps. . . . You cannot win wars by forming committees, neither can they be won by selfish individualism. The individual must be prepared to efface himself in order that the whole may be more and more."

So much for national organisation *versus* individual competition.

6. The Need for the Diffusion of Science.

The next point which I would urge, though it is somewhat outside the main subject of this paper, is the necessity for a more widespread distribution of scientific knowledge, not among scientific workers, but among the general public, including statesmen and civil servants. The teaching of science, like that of some other subjects, has become far too highly specialised. I have sat on a University Committee with a number of Professors discussing the subjects for matriculation where nearly all the members requested that their own subjects should not be included as they preferred that boys entering their classes from school should have no previous knowledge thereof in order that the boys might then be professionally trained from the start. When I was a school boy the Polytechnic in Regent Street was a place of very popular scientific entertainment, Pepper's Playbook of Science was an ordinary school prize, but more important than these were the popular lectures given in the School of Mines in Jermyn Street by such men as Huxley, Tyndall and Frankland, quite free to the public. Let us retain a strictly scientific course of training for the youth who is to make science his profession, as we provide professional courses for architects, engineers, lawyers, doctors and other professional men, but let us endeavour to secure that the educated public shall have such a general knowledge of the phenomena of Nature and of the more important manufacturing processes that Members of Parliament will cease to wonder whether we shall *ever* know why the moon appears to change her shape, and we shall not be told that lard has only just been discovered as a source of glycerine, that mineral oil from Galicia is equally useful for this purpose, that wool will take the place of cotton in the manufacture of nitro-cellulose for propellants, or that a cargo of phosphate has been seized lest it should be used by the enemy for the manufacture of phosgene gas. As far as I know, the only connection between phosphorus (the light producer) and phosgene (the product of light) is that the former emits a brilliant light when burned, and shines in the dark when exposed to air, while the latter is commonly made by exposing to sunlight a mixture of carbon monoxide and chlorine, the light causing the union of the gases.

In this connection very great services might be rendered by the press, not so much by the publication of scientific articles as by encouraging the resuscitation of what I may call popular science as part of a general education, both in school and after school days by suitable books and lectures. *Nature* has set a good example in this respect. Thirty years ago, before the coming of the kinematograph, when its precursor, the zoetrope, afforded the best example of moving pictures, audiences of several hundreds were common at scientific lectures, outside the Royal Institution. Now the classes of the Workers' Educational Association have partly taken the place of University Extension lectures. The classes are small, which is a good feature for systematic training and the encouragement of free discussion, but they are generally on social or economic questions, and science in its pure form or in its application to industry receives

little attention outside the professional circle.

It was publicly stated some weeks ago that Lord Haldane once promised that if the Liberal Party came into power there should be a due proportion of scientific men in all Government offices. This result has not yet been brought about by the Commission on the Civil Service. Perhaps this is another field for the influence of the press, but it must always be borne in mind that in administrative work, where the dealing is with men rather than things, the student of the Humanities has a great advantage. Though I am pleading for a much more general knowledge of science among Civil Servants, I am not prepared to recommend that a large proportion of the Civil or Municipal Service should consist of scientific specialists who have made science their principal subject of study. There should be a small proportion of such scientific men in every Government office, selected according to the nature of the work of the department concerned; and a larger proportion in some departments. The Board of Trade, the Admiralty and the Ministry of Munitions, for example, require a great many scientific members on the staff, but as Government and Municipal offices are at present conducted the success of an administrative officer depends not so much on his knowledge of the right thing to do in order to achieve the greatest advantages for the community as on his power of gauging what his superior officers, or Parliament, or his local authority, are prepared to permit him to do. The officer who proposes the course of action which other people are desiring to take, though they have not formulated their desire, succeeds in public life; the officer who studies things rather than character and proposes what is absolutely the best, but is a few years in advance of public opinion, is a failure in official life though he may live to see all his proposals carried out—by others. This goes far to explain the success in administrative work of the Oxford student of the Humanities and the advantages offered to him by the Civil Service examinations. The choice of convincing words and elegance of diction will, perhaps, complete the explanation. An examination for Class I., based mainly on science, would bring men to the top of the list who would afterwards be declared to be administrative failures. Sometimes, of course, the scientific man possesses also the power of gauging public opinion and the readiness to waive his scientific conclusions for the present. He may even be a member of the Fabian Society; but the power to quote Plato and Aristotle as authorities still counts.

7. The Case for Scientific Research.

After all that has recently been written on the subject there is no occasion this evening to recite the history of the application of science to industry in order to prove the desirability of encouraging industrial research. Few persons to-day will doubt that even the purely scientific investigator, if allowed suitable facilities for his work, and adequately assisted in its practical development, can afford very great aid to industry. Certainly we need not go back to the Davy safety lamp, or Faraday's discovery of the "magnetic spark," the origin of every electric generating station in the world to-day, when we have seen produced in the last few months the anti-gas helmet, which has been so effective in protecting the soldiers on the Western Front. Only a very short time ago a research student at Manchester, working for his M.Sc. degree, developed a method of enabling a generator to take a much greater over-load than had previously been possible, and within a year a rotary converter of 500 kilowatts capacity, was installed and working at the Salford Generating Station on his design. I have frequently contended that the phenomenal rate at which electrical engineering advanced during the early years of its recognition as a profession was due to the number of university men trained in mathematics and physics who took up the subject and to the facilities provided by educational laboratories. The experiments of Hertz, apparently of no practical value in their results, based on Maxwell's electromagnetic theory of light, which when enunciated by him in 1865 appeared to be not simply in the clouds but far above them, have, in the course of a few years, produced wireless telegraphy; but between the work of Hertz and a Marconi

Transatlantic station there has been an immense amount of patient labour which affords an illustration of what is sometimes required in the second stage of scientific research to which I shall presently refer more particularly.

8. The Advisory Council for Research.

I suppose that the appointment in July last by the Minister of Education of an Advisory Council for Research has been generally welcomed, except by those who think that the Scientific Societies ought to be able, of their own initiative, to create all the machinery required not only for the work needed in the department of each, but also for the joint action of several where industrial interests overlap. Provided that the Advisory Council is entrusted with the distribution of adequate funds and with powers sufficient to secure that its advice will be followed, and provided further that it does not attempt to do everything off its own bat, but fully utilises the services of all the scientific, professional and trade societies willing to co-operate in proposing subjects for investigation, selecting the institutions where the work can be carried out, choosing the workers and superintending the investigations, it may render services of extreme value. It is also important that the laboratories of universities, colleges and technical institutions should be utilised for organised research to the utmost extent compatible with the educational work for which these institutions were primarily founded, but when this is done it will be found that a great many new institutions will be required and must be established under the guidance of the Advisory Council, and, perhaps, to a great extent, through funds provided by Parliament, though much of the money required should be provided by the trades interested. The duties of the Advisory Council are thus set forth by the President of the Board of Education :—

"The Primary functions of the Advisory Council will be to advise the Committee of Council on :—

"(i.) Proposals for instituting specific researches ;

"(ii.) Proposals for establishing or developing special institutions or departments of existing institutions for the scientific study of problems affecting particular industries and trades ;

"(iii.) The establishment and award of research studentships and Fellowships."

The President of the Board of Education states that there must be a single fund for the assistance of research for the Kingdom as a whole, under a single responsible Body. That Body is a Committee of the Privy Council comprising half-a-dozen Ministers of the Crown and certain non-official Members. It is nominally the function of the Advisory Council to advise this Committee, but, presumably, the main function of the Committee is to act as an intermediary between Parliament and the Advisory Council in connection with the appropriation of Parliamentary moneys.

Dr. Fleming, in his paper read before the Royal Society of Arts on February 9th, said : "This war is a war quite as much of chemists and engineers as of soldiers and sailors. Hence, from the point of view of national security alone, we must take steps to foster scientific investigation." The War Office, the Admiralty and the Ministry of Munitions have taken steps for the period of the war. For a permanent institution, the Government has established the Committee of Council, and the Advisory Council for Research. As in other cases the Committee of Council may, in course of time, be replaced by a new Ministry.

There are many men of science who deprecate any State interference with research, and Dr. Fleming is apparently one of these ; but in the paper already referred to he says : "No great enterprise can be carried out unless there is some degree of surrender of initiative and acceptance of direction from a higher command. To carry out this principle in scientific work it appears to me that we require to a fuller extent than we have it at present the system of scientific work done to order." Hitherto there has been no sign of the "higher command" coming from the Royal Society or from any combination of scientific societies. The British Association is almost the only body which has successfully attempted the organisation of

research, and the time has come when the Government should take the matter in hand.

The main work for the Advisory Council is well indicated by another statement of Dr. Fleming: "If some men are to surrender initiative in their work, then others must give time and thought to planning the outlines of the scientific campaigns. We need not only the Regimental Officers, but the General Staff, if there is to be effective achievement." Another requirement is set forth by Dr. Fleming thus: "We have to formulate in precise detail the suggestions for future work, and bring them to the notice of those who may be able or willing to work them out." Herein the Advisory Council will need all the assistance which can be given to it by the scientific, professional and trade societies and the technical and scientific journals representing them, as well as by individual manufacturers and scientific experts.

There are two methods by which the Advisory Council may secure the necessary "touch" with industrial interests. The better of the two is the voluntary formation by the traders themselves of Associations or Committees to advise the Council and work in conjunction with it and, to some extent, under its guidance, while they themselves enjoy the full confidence of the trades they represent. The other method is the formation of Committees for particular trades or groups of trades by the Advisory Council itself which would invite leading members of an industry to form a Committee which would come between the Advisory Council and the Trade.

9. The Stages of Industrial Research.

Broadly speaking, the results of industrial research may be divided into two classes—those which relate to improvements in processes or appliances already widely used and those which introduce entirely new products or methods of manufacture, generally necessitating large capital expenditure before they can be commercially applied. To this distinction I shall have to refer later on. The work which is involved in developing the results of discoveries so as to render them successful when applied on a commercial scale varies in different cases as much as the character of the investigations which led to them, but in very many cases three stages may be recognised in the whole process:—

(1) *Inception.* The purely scientific investigation conducted in the research laboratory, frequently with no definite practical object beyond the desire on the part of the investigator to extend the boundaries of knowledge.

(2) *Adaptation and Standardisation.* The practical adaptation of the discovery to a manufacturing process on a small scale; the testing of the results and the removal of the difficulties which occur in practice; the standardisation of processes and parts.

(3) *Commercialisation.* The adaptation of apparatus and processes to manufacture on a commercial scale where cost of production is a prime factor.

As pointed out the other day by Sir Wm. Tilden, Britain and France have been prominent in Stage I. Germany's success has probably been largely due to her patient work in Stage II.

10. The College Laboratory.

Sometimes all three stages are carried out in the works purely in the interest of one firm; and in this case the public may in course of time purchase the goods but they will learn nothing about the investigation. Research conducted in this way will continue, but will not generally come under the purview of the Advisory Council or any public authority. For researches conducted with the aid of public money considerable provision is made for the first stage in the laboratories of university and technical institutions where professors and other teachers work with their students, both pre-graduate and post-graduate. Much of the students' work has purely an educational aim, providing training in methods of research which the student may afterwards apply with a more definite industrial object, but even such work may lead to results of great intrinsic value, as in the case of the Salford generator already mentioned. Work of this type is carried out by the research scholars appointed by the Commissioners of the 1851 Exhibition, and it is very desirable that the number of these

research scholarships should be increased and that university graduates who are looking forward to occupying leading positions in industry should gain in this way some experience of the methods of research. But other investigations in the college laboratory may be conducted with the special object of solving some industrial problem. Many such investigations have been carried out since the commencement of the war for the Admiralty, the War Office and the Ministry of Munitions. In a schedule of such work prepared by certain universities I noticed more than a dozen items deleted by the Press Bureau, which appears in itself to be sufficient evidence of their value, while it also suggests to me the undesirability of talking about them. More research professors, more research scholars and more laboratory accommodation, with more liberal equipment, will undoubtedly be required if sufficient provision is to be made for Stage I., but the first step which should be taken by the Advisory Council is the preparation of a schedule showing all the existing provision in public educational institutions, the qualifications of the superintendents of the laboratories and their assistants, measured not by their degrees but by the original work they have done, and the number and status of the students assisting in original work. The schedule would include laboratories for all branches of engineering, chemistry, metallurgy, physics, botany, geology, bacteriology, and, perhaps, biology and physiology. Certainly the physiological laboratories have been called upon to undertake very important investigations in connection with the present war.

11. Work for Trade Societies.

Of the investigations conducted in these laboratories many would be initiated by the teachers in charge, others would be carried out on the recommendation of professional or trade associations, others again at the request of commercial firms, and some would be suggested by the Advisory Council itself. The work of the Advisory Council may be greatly relieved by trade associations, who will ascertain the facilities for research in their district and introduce the manufacturer to the superintendent of the laboratory, a suitable report being sent to the Advisory Council, but in some cases the Council must itself invite trade societies and professional institutions as well as private firms to bring directly to them problems requiring solution. In connection with the Research Fellowships established by the late Dr. Duncan in the United States, the manufacturing firms who provide the expenses of the Fellowships state the particular problems which they desire to be solved in the university laboratories, and offer facilities in their own works for any part of the investigation for which the university laboratories are less suitable. I am told by Mr. A. P. M. Fleming that most of the Fellows who have carried out these researches have entered the industries concerned.

There are those who urge that scientific research should be left entirely in the hands of scientific men and their associations without any interference on the part of a State-appointed committee. There is much to be said for the view that there should be no interference on the part of such a committee with research spontaneously undertaken by scientific workers, but for the discovery and solution of problems of industrial importance some machinery is required which will bring the manufacturers and scientific investigators into much closer association. It is the nature of this machinery on which opinions differ. I have indicated above the two forms which I think it might take.

12. Adaptation and Standardisation.

For the Second Stage, the facilities afforded by public institutions are less extensive than for Stage I. There are some technical institutes in which adequate provision is made, both for Stage I. and Stage II., except that if the institute is a monotechnic institute and not part of a much larger institution the co-operation of professors of other branches of science or technology is lacking. In the Leathersellers' College in Tower Bridge Road, skins can be tanned, dyed and dressed ready for market, and rendered quite as saleable as in a commercial leather works, but the output is necessarily very small. The College also possesses analytical and research laboratories designed to suit all

the requirements of the director of the school, who has a very high reputation as an investigator of questions connected with the tanning and dressing of leathers. Similar conditions obtain in the tanning department of the University of Leeds under Professor Procter. The L.C.C. School of photo-engraving and lithography is equipped for research in photo-process work, and it can turn out blocks comparable with the best in the trade, but it is not in a position to take an order for a number of half-tone blocks to be delivered the same day. Here, as in the leather works, the output consists of distinct units and the processes are the same for a single skin or process block as for a thousand. This is not the case with pig-iron or sulphuric acid or soda crystals. In many of our manufactures the process must be carried out on a large scale, but even in some of these cases technical colleges are provided with the necessary equipment for Stage II. Steel manufacture is thus treated in the University of Sheffield and provision is made for some other branches of metallurgy in the Imperial College at South Kensington. Cotton spinning and weaving, calico printing and paper-making are treated on a commercial scale in the Manchester School of Technology, and the woollen industries in the University of Leeds, at Bradford and elsewhere. In these institutions there is provision for laboratory research, for manufacture on the commercial scale and for testing the results, mechanically and otherwise. In the engineering laboratories of all the higher institutions there is more or less adequate provision both for Stages I. and II., especially in connection with mechanical engineering, including "prime movers," and electrical engineering. Structural engineering cannot, of course, be carried out in the laboratory, for the small scale model has entirely different mechanical properties from those of the full scale structure. Geometrical and dynamical similarity are not governed by the same laws. In structural engineering the ordinary laboratory can do little more than test materials and fastenings.

But while for a very limited number of industries provision can be made, both for Stages I. and II. in the college laboratory and workshop, and in some there is no need for special experiments under Stage III., in many of the most important branches of work it is not possible to provide even for Stage II. in the college laboratory, and if it were possible it would be undesirable to take up the time of the professional staff with the supervision of the great amount of routine work which is often involved in what I have called "Adaptation and Standardisation." It is easy in a college laboratory to provide facilities for electrical experiments at high voltages, 20,000 or 30,000, or even 100,000 volts. It is only necessary to take precautions for the safety of the workers. But it is not possible in these institutions to provide large currents of, say, 3,000 or 5,000 amperes without great expense for very occasional use. Similarly, a metallurgical laboratory may be fitted up with hand apparatus for testing the malleability and ductility of metals and alloys, but a rolling mill for the preparation of plates and bars from which test pieces may be cut is a desideratum which, even on a very small scale, cannot be supplied to every metallurgical laboratory.

13. The National Physical Laboratory.

For standardising scientific apparatus and testing the physical properties of materials the institution *par excellence* is the National Physical Laboratory at Teddington. This laboratory, with its 250 skilled workers devoting their whole time to measurements, and processes antecedent to measurements, fills many a gap which previously existed in the facilities afforded for Stage II., at least as far as standardisation is concerned. The Laboratory comprises :—

A department for pyrometry, with electric furnaces working up to 3,500° C.

A department for the testing of thermometers, including clinical thermometers.

A special room for the testing of radium by a standard consisting of 21 milligrammes of radium chloride.

Apparatus for testing thermal conductivities and a laboratory for the examination of mineral oils.

A department for magnetic and electrical measurements, comprising appar-

atus for testing the magnetic properties of samples of iron and apparatus for measuring electric capacity and inductance at various frequencies.

A laboratory for wireless telegraphy, including a camera for photographing sparks up to 2,000,000 a second.

An electrical standardising laboratory with standard cells and apparatus for weighing electric currents and for measuring directly very small resistances.

An arrangement for testing compasses.

A department for testing watches clocks and chronometers at high, medium and low temperatures.

The optical department for testing sextants, theodolites, clinometers, telescopes, binoculars, spectacle lenses, photographic lenses and other photographic accessories, telescope object glasses and spectroscopes.

The department of electrotechnics, with facilities for working at high voltage, up to 100,000 volts, and with currents at low voltage, up to 6,000 amperes, including the testing of commercial and other measuring instruments.

A laboratory for photometry, with special reference to the testing of arc and glow lamps and determining the life of the latter.

A room for illustrating different methods of lighting, which was equipped for the Home Office Committee on Factory Lighting.

The very important department of metrology, with arrangements for measuring tapes or wires up to 50 metres, comparators for testing standards of length up to 4 metres, testing apparatus for gauges, &c., measuring to 0"·00001, apparatus for measuring all the features of a screw and for cutting standard screw threads, appliances for testing barometers and aneroids and for measuring to 1 part in 1,000,000 standards of mass from 1 gramme to 50 kilogrammes and apparatus for testing taxi-meters.

A laboratory for engineering tests and research, capable of testing materials in tension, compression or bending up to 100 tons. This laboratory also comprises apparatus for impact tests and for testing materials under rapid reversals of strain, up to 2,500 reversals per minute, apparatus for testing gauges up to a pressure of 24,000 lb. per square inch and testing water meters. Research apparatus has been fitted for several investigations of interest to engineers.

An aeronautical laboratory, with wind channels, whirling table for testing propellers, and two experimental towers 60 feet high with revolving platforms for exposing large models to the wind.

A special department for making up experimental road surfaces and testing them and the materials used in their construction.

The Wernher department of metallurgy and metallurgical chemistry, with very complete appliances for photomicrographic work, a foundry where large castings (2 or 3 tons) can be made, a testing laboratory, a furnace room, a rolling mill for alloys used in aeronautics, and chemical laboratories for steel analysis, the analysis of alloys, gas analysis, and for research work on road and aeronautical materials.

Last, but not least, is the William Froude tank, 550 feet long, with all its accessories for making and testing ships' models.

This schedule is very far from complete and is intended only to give an idea of the scope of the National Physical Laboratory.

14. Requirements for the Chemical Trades.

For the chemical trades and other trades dependent upon them we have nothing which quite corresponds to the National Physical Laboratory. Much has been said lately about the manufacture of optical glass, and I will not here repeat it. Primarily, this is a chemical industry though the conditions which the glass is desired to fulfil are those laid down by the designer of optical instruments and belong essentially to the department of physics. The glasses made can be tested at the National Physical Laboratory, and lately a small furnace for glass-making has been provided there, but we have no public institution adequately equipped with appliances for making the glass and for cutting and grinding it into plates, prisms and lenses. The Optical Institute, which it was proposed to establish in London, would have met the requirements of the optical instrument-maker both for Stage I. and

Stage II. A national Industrial Chemical Laboratory would have for its principal object the standardisation of chemical operations invented in the research laboratory, so as to ascertain precisely the conditions under which reactions take place most favourably and at the least cost, and the methods of securing a sufficient degree of purity in the product; but the great diversity of operations required in manufacturing chemistry will probably render it impossible to establish a single institution for chemistry corresponding to the National Physical Laboratory. In mechanics and physics it is possible to provide a set of apparatus capable of making nearly all the measurements likely to be required. A department of metrology, for instance, will suffice to measure linear dimensions of any materials for whatever purpose they may be used. Similarly a well-equipped electrical standardising department will deal with the electrical features of almost any appliance which may be submitted, but nearly every branch of manufacturing chemistry, when it has passed the laboratory stage, requires separate treatment. It is quite true that dyeing materials and high explosives have much in common in the basis of their composition, and it was the accidental explosion of a dyeing material, viz., picric acid, in Manchester, which gave the start to the manufacture of a number of high explosives; but the tests which have to be applied to dyes and to explosives are so widely different that there would be no point in dealing with them in the same institution. In chemistry, therefore, there is much to be said for the monotechnic institution, or the standardising laboratory which deals with a single group of trades such as dyes, explosives, artificial manures, mineral colours, oils and fats, cements, glass, pottery, drugs, rubber, fibres (including paper), flour, bread, and so on. The Society of Chemical Industry recognises 26 groups of chemical trades in their classification of inventions. It would be difficult for any single committee to keep even a general oversight over such multifarious institutions and processes, and therefore most of these standardising laboratories should be directly managed by the trades concerned. This, I know, brings us face to face with the greatest difficulty we are likely to have to meet, and it is that of the distribution of information. Chemists, beyond all other manufacturers perhaps, appear to believe in the policy of secrecy. Success in international competition implies unity of purpose and community of knowledge throughout the industrial army, and this further implies division of labour on an economic basis. Let knowledge be common and let each manufacturer do the work which he can do best and most economically. We may at least borrow this measure of co-operation from the Germans, and it is only in this way that we may hope to secure joint action in the maintenance of a standardising laboratory which shall be conducted in the interests of every member of a trade or group of trades, whether directly at the cost of the trades or subsidised by public money. Where trades are mainly local the laboratory should be in the same locality. If the press could help in uniting the members of the trades to take joint action in their common interest and that of the industry of the nation it would be doing most excellent work. Manufacturers would not be called upon to reveal secrets they already possess, or new secrets which they may themselves hereafter discover, but they should be persuaded that, as a rule, they will gain more than they will lose by sharing the knowledge acquired through combined industrial research.

Trade committees, either local or national, should be formed, whose business it should be in the first instance to ascertain what facilities already exist in the universities or technical institutes for conducting investigations connected with their trade, and to negotiate with the Advisory Council respecting the provision and maintenance of any other institution which may be necessary, especially for the purposes of adaptation and standardisation. Their paramount work would lie in ascertaining from the members of their trades the problems requiring solution and in apportioning these problems to the suitable institutions and the appropriate workers.

There is an extensive field for the national provision of increased facilities

for standardisation under the auspices of the Advisory Council for Research, both in the extension of the National Physical Laboratory and, in co-operation with the several trades, in the provision of corresponding facilities in chemistry, including metallurgy, in bacteriology, and, possibly, in other departments of applied science. At first it may be necessary to employ funds provided by Parliament, but if the results of the investigations are adequately protected in the interests of the State the income derived should, in the course of a few years, suffice for all purposes of maintenance.

15. Commercialisation.

Except where factories exist for Government purposes, as in the case of the Royal Dockyards and Arsenals, the final steps in the development of an invention, which I have included in Stage III., will necessarily be carried out in the commercial works. In some cases very little expenditure on experiment will be required at this stage. In other cases entirely new plant will have to be designed and constructed and new factories built. Elsewhere I have suggested that whenever an invention has been developed wholly or partly by means of public money the patent rights should be vested in the State if the State is advised by competent authority to accept the invention. The manufacture should be distributed as widely as possible under payment of a royalty, an adequate share of which should go to the inventor, while the cost of administration and the maintenance of the research laboratories to which I have referred, should be a charge on the remainder. It is from this source that I expect ultimately to meet all the costs incurred by the Research Council. Until this source of income is adequate I think that all the expenses I have recommended would be a very proper charge on the Development Fund. Most inventions will be of the nature of improvements in existing processes and then there will be no difficulty in granting licenses under a State Patent to every member of the trade willing to pay the fixed royalty. Other patents will relate to new processes involving great expenditure in plant and in these cases the issue of licences must be restricted or no one will incur the expenditure in face of unlimited competition. In theory, the Patent Law exists solely to provide for these cases. I am quite aware of many difficulties associated with the proposal for State patents. There will, no doubt, be a tendency for research students, though working with public funds, to sell privately any successful results to manufacturers who are willing to purchase, and this cannot be entirely prevented, but in the majority of cases the superintendents of the laboratory would be acquainted with the progress of the research and no private patent should be held good if it can be shown that it is based on work done in a laboratory wholly or partly maintained by public money. Manufacturers, too, will not be very ready to purchase if they know that the law is against them when the facts come to light. Moreover, in the case of a State Patent previous publication ought not to be a bar. In this I agree with Sir Oliver Lodge. The main discovery is frequently made without any thought on the part of the conductors of the research of its practical application, and is published as a matter of purely scientific interest. When the useful application is made, both the original inventor and the originator of the application to a useful purpose should have a share in the profits.

16. The Industrial Bank.

The invention which leads to the establishment of a new industry raises in an acute form the question of finance. When a body like the Research Council is sufficiently confident of the value of an invention to recommend that it be the subject of a State patent an opportunity appears to be offered to the Industrial Bank, which may be a separate banking company or a branch formed, as recommended by Mr. Olsson, by all the principal bankers for the sole purpose of advancing industrial undertakings. The Technical Advisory Committee, which protects the interest of the Industrial Bank in Germany, would be less necessary when the State has been advised to accept the patent.

17. An Alternative.

A special Committee recently appointed by the Engineers' Club of Manchester has reported that it "is convinced that the British Engineering Industry must organise without delay to take advantage of present opportunities and to meet the conditions which will follow the termination of the war. In our opinion Germany's success has been due to education, to co-operation, and to organisation in manufacturing and selling, backed up by adequate financial support. In Britain, on the other hand, education has been unsystematic, organisation weak, and co-operation between competing firms almost non-existent." Among other matters the Committee recommend the placing of the Consular Service on a more business-like footing, the collection and dissemination of information, advising with respect to the education of engineers and the establishment of new schools and colleges where necessary, as well as scholarships and bursaries, the organisation of research, and the creation of a Ministry of Industry and Commerce with a permanent secretary of great commercial experience and distinction. Work of this kind necessitates in the first instance confidence between the members of the industry. The establishment of this confidence is the principal and the most difficult task in which the scientific and technical press can assist. It is estimated that the capital invested in engineering works is not less than £300,000,000. An annual subscription of one-tenth per cent. on this would provide an income of £300,000 a year. This would provide all the research institutions and all the research workers which could reasonably be required and leave a sufficient margin for the other objects proposed. If the engineering and other trades would organise on this basis they would be independent of the State and the assistance of the Advisory Council would be required only to bring together different associations to deal with matters of common interest. This is an alternative method of solving the problem.

Steps are already being taken by the Chemical Society, the Society of Chemical Industry and the Dyers and Colourists to bring together the chemical trades into a similar association.

18. Summary.

My suggestions may be summarised as follows :—

1. Education in elementary and secondary schools must be more directly associated with *things* so as to develop self-reliance and resourcefulness, not to teach trades.

2. A considerable proportion of teachers should devote a third year of training largely to practical work under conditions enabling them to become acquainted with the practice of some trades.

3. A general knowledge of the phenomena of nature and of processes applied in industry must be more widely diffused by means of popular lectures and otherwise.

4. More completely organised courses of instruction, without breach of continuity, must be provided for industrial workers of all classes, including the leaders of industry, together with the necessary scholarships, fellowships or bursaries to enable the best students to carry on post-graduate research.

5. Existing institutions must be improved and some new institutions must be provided, especially in the chemical trades, to enable scientific discoveries to be developed sufficiently to demonstrate the conditions under which they can be made commercially successful.

6. Some alterations must be made in the patent law to enable the profits arising from investigations conducted wholly or partly at the public expense to be fairly divided between the State, the scientific worker and the manufacturer.

7. Trades should be organised for the purpose of superintending the research work in which they are interested, for the collection and dissemination of information and the distribution of work among firms in the manner in which it can be most effectively and economically carried out in the interest of the industry as a whole.

8. The trade associations should be in close touch with the Advisory Council for Research, and the Council should, where necessary, recommend the award of Parliamentary grants in aid of industrial research carried out under the direction of the associations and make provision for such work in cases in which trade associations are not available, but the

Advisory Council should utilise to the utmost the services of these associations and of professional and scientific societies.

9. As an alternative the Advisory Council for Research should appoint technical committees representative of trades, or groups of trades, to assist it in the organisation of Industrial Research.

10. The National Physical Laboratory should be the central institution for all physical measurements and standardisation, but for chemical processes a separate institution for a trade or group of trades will frequently be required for the work intermediate between the discovery of a new product or reaction in the research laboratory and the adaptation of the process to commercial manufacture.

11. Some method of financing new processes which have been approved by a competent authority, other than the ordinary method of floating a company, is desirable and this may be provided by some form of industrial bank.

19. War Economies.

I cannot conclude this paper without referring to the immense service which the scientific, as well as the popular, press can render to the nation by advocating rational economies in this present crisis. With some reason the public complain that they are urged to economise but are not told wherein economy can be wisely exercised, and they are still obsessed by the principle, which was quite sound during the first few months of the war, of "Business as Usual." Sometimes we are advised not to consume imported food, but we cannot, as a nation, live without a very large proportion of imported foods, and it is clear that if we continue to consume meat at the present rate and demand English meat exclusively, we shall soon lose all our breeding stock and milk supply. To reduce the importation of meat we must reduce our consumption. We want to be told what foods involve the least injury to the nation's credit and make, for their transport, the smallest demands on our Mercantile Marine. We want also more general instruction on food values, especially substitutes for meat. The public must be taught to recognise the treason to themselves and their country involved in the purchase of new clothes for the sake of fashion, and fashion itself should be interned as an alien enemy for the period of the war. In particular those materials, such as leather, of which the supply is largely required for our Army and the Armies of our Allies, should not be purchased except for urgent need. I do not think that economy should be exercised by reducing salaries; this will not necessarily benefit the State except in the case of salaries paid directly from the Exchequer. The only useful economy lies in ceasing to consume unnecessarily the products of labour, while the pecuniary savings thus effected are invested in war loans. This, in effect, is simply a transfer of labour from the service of the individual, to whom it is a superfluous luxury, to the State to which it is in the present crisis a dire necessity.

[A reference to the proceedings at this meeting was made in an Editorial in the ILLUMINATING ENGINEER for March, 1916, p. 76. At the conclusion of Dr. Garnett's paper an introductory address was given by Mr. A. P. M. Fleming, and a discussion then ensued in which Prof. Gregory (*Nature*), Mr. E. Pendred (*The Engineer*), Dr. R. M. Walmsley (Principal of the Northampton Institute), and Mr. W. R. Cooper (*Electrician*) took part. Dr. Garnett and Mr. Fleming briefly replied to the discussion. Finally a resolution expressing the desire of the Circle to be of service in bringing about a fuller appreciation of the value of technical education and industrial research, and in promoting unity of effort in the study of these subjects was proposed by Mr. Gilbert Wood, seconded by Mr. J. S. Dow, and carried unanimously.

The discussion was resumed on May 16th, when an introductory address, summarising recent proposals for the organisation of science, was given by the Chairman (Mr. L. Gaster). In the unavoidable absence of Mr. Hughes, Prime Minister of Australia, an address was given by Mr. Gerald Lightfoot, who is intimately associated with the establishment of a National Institute of Science and Industry in Australia. Among others who took part in the discussion were the Rt. Hon. A. Dyke Acland, Sir John Cockburn, Prof. R. A. Gregory, and Mr. A. J. Mundella, and a further resolution, supplementary to that passed on March 14th, was proposed by Dr. W. Garnett, seconded by Mr. E. J. Benn, and carried unanimously.

We propose to give a full account of these proceedings in our next issue.—ED.]

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL GENERAL MEETING.

(Held at the House of the Royal Society of Arts, London, W., at 5 p.m. on Tuesday, May 9th, 1916.)

THE Annual Meeting of the Society took place as stated above, the chair being taken by Professor Silvanus P. Thompson, D.Sc., F.R.S.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership announced at the last meeting, and these gentlemen were formally declared members of the Society.*

The HON. SECRETARY then presented the Report of the Council for 1915—1916 (see pp. 169).

The CHAIRMAN said that it was matter for congratulation that, in spite of all difficulties, the work of the Society had been uninterrupted, and five meetings of considerable interest had been held. The activities of the Society had received official recognition, and it was also gratifying for the work of a young Society to secure, as it had done, the co-operation of the older and more specialised bodies. The Chairman also alluded to the death of several members of the Society during the war, including two valued Vice-Presidents, Prof. Vivian Lewes and Mr. Edward Allen, both of whom were widely known for their active work in the gas industry.

Mr. F. W. GOODENOUGH (Chairman of Council), in moving the adoption of the Report, said that the remarks of the Chairman on the loss of Mr. Allen and Prof. Vivian Lewes would be widely appreciated. Both might be said to be victims of the war, for Mr. Allen had taxed his strength by extra work on the Explosives Committee of the Ministry of Munitions, and it was while engaged on similar duties that Prof. Lewes caught his fatal cold.

Turning to the Report, Mr. Goodenough said he shared the general satisfaction in the good work done in such difficult circumstances, and it was all the more regrettable that on the financial side the Society, like other institutions, was feeling the strain of the war. It was to be hoped that some of the undertakings which derived benefit from the good work the Society was doing would see their way to assist the Society in this direction.

* *Illum. Eng.*, April, 1916, p. 117.

The continued usefulness of the Society was due very largely to the zeal which the Hon. Secretary had brought to bear on its proceedings, and the Society owed him a debt of gratitude for his services.

He had pleasure in proposing: "That the Report of the Council for the Session Nov. 1915—May 1916 be formally adopted by the Society."

The resolution was seconded by Mr. O. P. MACFARLANE, and having been put to the meeting was declared carried unanimously.

Mr. L. GASTER (Hon. Secretary) briefly expressed his appreciation of the kind remarks of Mr. Goodenough, adding that the work had been much facilitated by the harmonious goodwill which existed between members of the Council. He had also to acknowledge the able assistance of Mr. Dow, as Hon. Assistant Secretary.

Mr. S. R. MULLARD then proposed:—

"That this meeting extends a cordial vote of thanks to the President, Council and Officers for their efforts on behalf of the Society during the past twelve months."

The resolution was seconded by Mr. J. F. CROWLEY and carried unanimously.

The CHAIRMAN, who incidentally regretted the enforced absence of the PRESIDENT, SIR WILLIAM BENNETT, on Army business, proposed the following resolution:—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received."

The Illuminating Engineering Society, he said, was one of the youngest of a long list of societies whose growth and expansion had taken place in that very room. It was necessary to read the record of the scientific work of the Royal Society of Arts during more than a century, prepared by its indefatigable Secretary, Sir Henry Trueman Wood, and published in book form two years ago, in order to appreciate the very useful work the Royal Society of Arts had done.

Mr. F. W. GOODENOUGH seconded the resolution, which was carried unanimously.

The HON. ASSISTANT SECRETARY (Mr. Dow) then read in the abstract the Interim Report of the Committee on Research (see pp. 172).

The CHAIRMAN remarked on the wide range of topics in the Report. There were many matters which obviously required co-operation with other bodies and might only be effectively dealt with after the war. It was, however, desirable to put these suggested researches on record so that they might receive attention at the opportune moment.

Mr. J. F. CROWLEY pointed out that several of the subjects were of vital importance to the textile industry, notably those bearing on the permanence of colours and the production of "artificial daylight." Such matters might well receive the joint attention of the Textile Institute and the Illuminating Engineering Society. When present at the recent Congress of the Institute at Manchester he had suggested the appointment of a Research Committee with similar aims to that formed by the Illuminating Engineering Society, and he hoped that this suggestion would bear good fruit.

Mr. R. C. BUSSEL likewise emphasised the need for co-operation with other bodies in researches on colour. A definition of a standard white surface would be of great scientific benefit.

Mr. Dow referred to the need for agreement on the colour of light utilised in a permanence-test.

On the motion of Mr. GOODENOUGH, seconded by Dr. R. LESSING, the Report on Research was formally adopted and a vote of thanks to the Chairman terminated the proceedings.

REPORT OF THE COUNCIL FOR THE SESSION (November 1915—May 1916).

Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W., at 5 p.m., on Tuesday, May 9th.)

THE Report of the Council for the Session 1915—1916 appears in the second year of war, and the circumstances alluded to in the Report for the Session 1914—1915 still continue.

Although during the past year a considerable number of members of the Society have joined the forces, and additions have been made to the number of those engaged largely or exclusively on war work, the activities of the Society have been fully maintained.

MEMBERSHIP.

The membership of the Society is substantially the same as last year—a result which may be considered very satisfactory in the present circumstances.

We have pleasure in recording that the Presidents of the Institutions of Gas and Electrical Engineers, Mr. John Young and Mr. Charles P. Sparks, have kindly consented to act on the Council during the present year.

The Council record with regret the death of two valued Vice-Presidents of the Society, Mr. Edward Allen and Prof. Vivian Lewes.

Among the losses caused by the War we notice two of the younger members of the Society, Mr. G. Maurice, who perished on the *Lusitania*, and Mr. F. Harvey Gooch, who fell in action with the Cameron Highlanders in France.

MEETINGS OF THE SOCIETY.

Five meetings, not including the Annual General Meeting, have been held during the past session.

The opening meeting on November 23rd was devoted to a discussion, initiated by Mr. L. Gaster, on the Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops. The object of this discussion was to make the contents of this important Report well known to members of the Society, many of whom are directly concerned with factory lighting, and to discuss how its recommendations can best be carried into effect by managers of factories and lighting engineers. The Report, which appeared in September, was generally considered to be of great value. It has a special application at the present moment, when so many factories are working overtime on Government contracts, and adequate industrial illumination is particularly important in view of its relation to the output and quality of work as well as the health of workers. The Report has received widespread notice in the technical press, and its recommendations will doubtless have a favourable influence on industrial illumination in this country. The Council desire to express their thanks to Dr. R. T. Glazebrook, the Chairman of the Home Office (Departmental) Committee, for his kindness in presiding over the meeting on this occasion.

The discussion on November 23rd dealt with the general conclusions reached in the Report. At a subsequent meeting on January 11th a further discussion was introduced by Mr. J. S. Dow, who presented photographs and data referring to a considerable number of gas and electric lighting installations. The discussion was useful in showing how, by modern methods, the requirements of the Report could be readily met, and in suggesting a few devices by which the illumination resulting from a scheme of lighting could be determined beforehand.

In view of the rapid progress recently made in connection with electric incandescent lamps and the influence, particularly, of the gas-filled lamps on modern methods of lighting, it was decided to devote a meeting to a discussion on "Recent Developments in the Electric Incandescent Lamp from the Illuminating Engineering Standpoint." This discussion was opened on December 14th, 1915, by Prof. J. T. Morris, who illustrated his

address by reference to a number of problems on lighting, in the solution of which special forms of lamps were employed. A feature of this discussion was the exhibition by Mr. S. R. Mullard, for the first time in public, of a new type of "arc incandescent" lamp, the source of light consisting of a ball of tungsten within a hermetically sealed bulb. The thanks of the Society are due to Professor Silvanus P. Thompson for kindly taking the Chair at this meeting.

Recent discussions, particularly that on factory lighting, have served to show the need for greater precision in specifying the amount of illumination required for various purposes. In order to describe the lighting conditions in such cases, it is clearly necessary to have available convenient and sufficiently accurate instruments for measuring illumination. It was therefore considered that the consideration of this subject would be timely, and on February 22nd a discussion on "Some Future Possibilities in the Design of Instruments for Measuring Illumination, with Special Reference to Chemical and Physical Methods," was arranged At this meeting a number of valuable suggestions for the improvement and simplification of illumination photometers were made, and several new types were described and exhibited. Previous to the meeting, a list of queries relating to points on which further information would be desirable was drawn up and circulated among members. By this means some useful information regarding recent advances in the use of selenium and photo-electric cells and other physical methods was received, the contributions from corresponding members in France and the United States proving particularly helpful in this respect.

Since the outbreak of war considerable difficulties have been experienced in obtaining certain varieties of glassware required in the lighting industry, and the fifth meeting of the Society, on March 21st, was devoted to a discussion on this subject. Instances of such difficulties, such as the lack of good heat-resisting glass and the finer varieties of white diffusing glass, were mentioned by Mr. S. B. Langlands in his introductory address on "Some Aspects of the Design and use of Glassware in Relation to Natural and Artificial Illumination," and confirmatory evidence was brought forward by other members of the Society. Various proposals were made with a view to improving present conditions, among them being the encouragement of research and the promotion of greater uniformity of design for articles in common use.

The Society had also the privilege of hearing the views of several members of the Glass Research Committee of the Institute of Chemistry, which has been conducting researches on chemical and optical glassware. From a national standpoint the future development of the glass industry is of considerable importance, and it is proposed to appoint a Committee of the Society to consider the problems involved in the manufacture and supply of glassware for lighting purposes.

Other Important Events of the Session.

Reference has already been made to the important Report issued by the Departmental (Home Office) Committee on Lighting in Factories and Workshops, which was issued last September. The Report appeared in the form of three volumes, comprising respectively (1) Report and Appendices; (2) Minutes of Evidence; and (3) Record of Observations in Factories. Amongst other recommendations, the Report proposes that inspectors should be given statutory power to demand in general terms adequate lighting in factories and workshops, and it is to be hoped that this recommendation will be carried into effect as soon as opportunity offers.

The Recommendations of this Report have also been brought to the notice of the Committee now sitting on the Conditions of Health of Munition Workers, and in the bulletins so far issued reference has already been made to the importance of good industrial illumination. Special mention may be made of Bulletin No. 9, on "Ventilation and Lighting of Munition Factories and Workshops," in which attention is directed to the Home Office Report, and the chief essentials of good lighting, as summarised in this Report, are repeated.

It will be the duty of the Society to continue their work on this subject with a view to bringing about wider recognition of the economic and hygienic value of good industrial illumination, and maintaining the interest kindled in these matters. It has been suggested that as a useful basis for further work, the Society might now pass from the general consideration of the subject to the preparation of information on the conditions of lighting applicable to various trades and industrial processes.

The question of factory lighting has also been receiving the attention of the American Illuminating Engineering Society, and at the last Convention, held in Washington in September, 1915, a most useful "Code for the Lighting of Factories, Mills, and other work places," prepared by a Committee of the Society, was presented. This has since been reproduced in THE ILLUMINATING ENGINEER.*

At the Convention a variety of interesting papers were presented, and the Transactions of the American Illuminating Engineering Society throughout the year have contained matter of considerable value.

A series of lectures on various aspects of illuminating engineering is also being arranged, which will doubtless serve to bring up to date the information contained in those given at the Johns Hopkins University (Baltimore, U.S.A.), in 1910. On the occasion of the celebration of the tenth anniversary of the founding of the American Society, an interchange of good wishes between the two Societies took place. The need for close co-operation in dealing with lighting matters is fully appreciated by the Societies on both sides of the Atlantic.

An important question that has been receiving much attention, both in this country and abroad, is the desirability of arriving at a uniform method of expressing the efficiency and illuminating value of gas, electric, and other illuminants. The view is now receiving support that lamps should be rated in terms of the total output of light in all directions. The following resolution has been proposed by the Committee of the American Illuminating Engineering Society on Nomenclature and Standards, and subsequently approved by the Council of that Society, and is recorded in the Report of the Council for the year ending September 20th, 1915* :—

> "(A) That the output of all illuminants be expressed in lumens; (B) that illuminants should be rated upon a lumen basis instead of a candlepower basis; (C) that the specific output of electric lamps should be stated in lumens per watt, and the specific output of illuminants dependent upon combustion should be stated in lumens per B. Th. U. per hour."

During the past year an influential movement for the encouragement and organisation of scientific and industrial research has been developed in this country. At a meeting of technical and scientific societies convened by the Royal Society on March 24th, a resolution was passed, unanimously advocating the formation of a Conjoint Board of Scientific Societies for promoting the co-operation of those interested in pure or applied science.

Attention has also been given to the scheme for the organisation of scientific and industrial research being prepared by the Committee of the Privy Council. The Illuminating Engineering Society will take steps to bring to the notice of this Committee any problems on which research would be beneficial in the interests of the lighting industry.

The Illuminating Engineering Society has intimated its willingness to take part in any movement calculated to bring about unity of effort in these matters, and to co-operate in any investigations bearing on the practical applications of light, in relation to illuminating engineering.

The Council also consider that the moment is opportune to proceed with the work of the Committee on Research, the appointment of which was decided upon in 1914, but was delayed owing to the outbreak of war. This Committee has held several meetings, and has prepared a Report for presentation at the Annual

*Vol. VIII. 1915, pp. 414, 441, 451; vol. IX. 1916, p. 135.

* Trans. Ill. Eng. Society (U.S.A.), No. 1, Vol. XI., February 10th, 1916.

Meeting, summarising various subjects for investigation which might receive the attention of the Society. The list of subjects has been made as complete as possible in order to show the variety of problems which require investigation. The Committee will consider which subjects should receive immediate attention, and will take the necessary steps to secure the co-operation and enlist the support of other bodies when dealing with problems of national importance.

ADDITIONAL SUPPORT NEEDED.

The Council are glad to be able to again record the gratifying fact of the Society being able to continue its labours, in spite of the unprecedented circumstances arising through the war.

The Society is fortunate in benefitting by the arrangement providing for THE ILLUMINATING ENGINEER to act as the official organ, and to undertake the publication of translations, the cost of which would otherwise be prohibitive, and has not been called upon to pay many customary expenses, such as rent of offices, secretary's salary, &c. Nevertheless the experience of the past year has served to emphasise the desirability of securing additional funds in order to enable the work of the Society to be carried on in a satisfactory manner. During the present circumstances the Council are unwilling to recommend any radical departure in this respect, but it is evident in the near future the Society must either secure a considerably enlarged membership, or increase its present moderate subscription to £2 2s., as was originally provided at the time of the foundation of the Society, or secure substantial support from such institutions as directly benefit from the movement.

The attention of members is also drawn to Article 23 in the Constitution of the Society where it is laid down that "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10s. 0d. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional funds.

PROGRAMME FOR THE NEXT SESSION.

The Council is now engaged in preparing the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible and to send in contributions during the vacation. The list of subjects for investigation at the end of the Report on Research may suggest some suitable subjects for papers.

SIR WILLIAM H. BENNETT,
President.

F. W. GOODENOUGH,
Chairman of Council.

LEON GASTER,
Hon. Secretary

INTERIM REPORT OF THE COMMITTEE ON RESEARCH.

(Presented at the Annual Meeting of the Society held at 5 p.m. on May 9th at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.)

THE appointment of this Committee was announced at the end of the Session in 1914, but owing to the disturbance caused by the war it was not found practicable at that time for the Committee to take up the tasks before it. The present moment, when so much attention is being devoted to the promotion of scientific and industrial research, appears favourable for the resumption of the work. An important step has been the appointment of a Committee of the Privy Council in order to study the organisation of Scientific and Industrial Research, and the Royal Society and other bodies are considering the best means of promoting unity of effort between the various scientific and technical societies of the country.

The following gentlemen have at

present been nominated to serve on the Research Committee of the Illuminating Engineering Society:—Mr. A. Blok, Mr. J. G. Clark, Mr. W. C. Clinton, Mr. J. F. Crowley, Mr. F. W. Goodenough, Lieut. Haydn T. Harrison, R.N., Dr. James Kerr, Professor T. Mather, Professor J. T. Morris, Mr. S. R. Mullard, Mr. C. C. Paterson, Professor Silvanus P. Thompson (Chairman), Mr. A. P. Trotter, Mr. F. W. Willcox; *ex officio* Mr. L. Gaster (Hon. Secretary) and Mr. J. S. Dow (Asst. Hon. Secretary).

The immediate object of the Committee was to prepare a list of subjects specially deserving of research at the hands of the Society, and the suggestions so far received, together with others arising out of past discussions of the Society, have been assembled in the list at the end of this Report. The Committee will welcome any additional suggestions, or intimations from members of any experiments which are already in progress. It is hoped that this list will also be useful in suggesting subjects for future discussions at meetings of the Society.

While not intended to be exhaustive the list already contains many more subjects for investigation than could be at present undertaken by the Society. It will, however, serve to show how past discussions have developed prospects of further useful work, and the many opportunities for research now before us.

In dealing with these suggestions the Committee may nominate from among its members sub-committees to organise or undertake specific researches or may take advantage of the services of other members of the Society or gentlemen outside the Society who have special knowledge of the proposed researches. Some of the investigations in contemplation will involve co-operation with other Societies and Institutions. The Society has been in touch with the various Associations and Committees for the organisation of scientific research, and it will be the function of the Committee to invite their co-operation on subjects of common interest and enlist their support in dealing with problems of national importance. The Committee will consider which subjects deserve prior attention, both with a view to their urgency and the prospects of obtaining the necessary support and securing favourable results in the near future.

There are on the list many subjects of great scientific importance which would involve long continued experiment and co-operation with other bodies, on such a scale as cannot reasonably be expected while the war continues; these matters will therefore have to be postponed for consideration at a later date.

In regard to matters connected with the war it is naturally impracticable to discuss in public all opportunities for service that may occur. Many members of the Society are already engaged upon work of this nature and any suggestions that they may bring to the notice of the Committee will naturally receive prior attention.

In connection with subjects of importance from the industrial standpoint the Committee suggest that priority should be given to investigations relating to the development of lamps and lighting appliances, and researches having for their object the elucidation of general problems on which the development of the lighting industry depends. As an instance, the investigation of the properties of illuminating glassware is a matter which, in the opinion of the Committee, should receive immediate attention at the hands of a special sub-committee appointed for the purpose.

Another subject which merits early attention in view of its relation to the dyeing and colouring industries is the preparation of a standard series of colours and in particular of a standard white surface, suitable for acceptance in all researches in which the accurate definition of colour is involved. Conjointly with this subject the design of suitable apparatus for analysing and specifying colour and for measuring the reflecting power of various materials should receive attention. There is also the further problem of providing a fixed standard for the permanence of coloured materials.

In dealing with this and the preceding matter the co-operation of other associations interested would be desirable.

In view of the growing recognition of the need for precise quantitative specifications of illumination required

in practice for different purposes, the preparation of a standard specification for illumination photometers, to be used in determining the performance of legal contracts involving the measurement of illumination, might be studied with advantage. The general question of the simplification of illumination photometers, and particularly the problem of producing a direct-reading instrument based on physical or chemical effects, which was discussed at a recent meeting of the Society on February 21st should also be borne in mind.

Among other matters which, in view of their important bearing on the future development of lighting, deserve special attention, may be mentioned :—the study of glare and the limits of permissible intrinsic brilliancy; the investigation of the comparative effect on vision and the physiological influence in inducing fatigue of natural and artificial illumination and of various systems of artificial lighting; and the conditions, as regards the intensity of illumination and arrangement of lights, desirable for various industrial operations. The latter question is of interest as being supplementary to the Report of the Home Office Departmental Committee on Lighting in Factories and Workshops, and it is suggested that the preparation of an illustrated Bulletin forming a guide to the best present practice in various sections of industrial lighting, might be undertaken.

In the list of researches the various suggestions have been roughly classified under the following headings :—

(*a*) Photometry, Standards of Light, and Researches on Colour.

(*b*) Electric, Gas and other Illuminants.

(*c*) Lighting Appliances.

(*d*) General.

(a) Photometry, Standards of Light, and Researches on Colour.

(1) *The Production of a Satisfactory Standard of Light.* It would be of interest to collect information furnishing a summary of the present position, preliminary to further researches, which would probably require action under the joint auspices of the National Physical Laboratory and the National Illumination Commission. This is essentially an international matter and only preparatory work could be done while the war continues.

(2) The development of a *Standard Laboratory Photometric Equipment* to take the place of those designed abroad. This again demands the co-operation of the National Physical Laboratory. In this connection the establishment of the suggested Central Optical Institute, where suitable photometric instruments with the necessary optical appliances could be developed, would be of considerable value.

(3) The specification of a *Series of Standard Colours* and of methods of determining the amount of light reflected from them and the general problem of a method of determining the total reflection from all kinds of surfaces, should be considered.

(4) The standardisation of *methods of analysing and specifying colour*, and design of simpler and more convenient instruments for testing the same. This is a matter of considerable scientific importance for the future development of the dyeing and colouring trades.

(5) The standardisation of the so-called "*Artificial Daylight*" (*i.e.*, the various forms of artificial light used in conjunction with special devices in order to imitate the colour of Natural Light). In investigating this question an attempt should be made to arrange the chief artificial illuminants in the order of their resemblance to daylight. This question has often been discussed but never authoritatively settled. At present there also appears to be no universally accepted *standard of* "*white light*" nor any generally accepted "*standard white surface.*"

(6) A closely related problem is the effect of different qualities of light on *the permanence of colours.* There does not appear to be any recognised and generally accepted method of testing the "fastness" of dyes, although various artificial illuminants have been proposed for use in this respect.

[(3), (4), (5) and (6) would require the co-operation of representatives of the chief industries concerned with coloured goods and coloured matching.]

(7) The subject of *colour-photometry*, on which much experimental work has been done, requires clearing up, but it is a vast problem, falling within the scope of the National Illumination Commission

and the National Physical Laboratory, and its full consideration would ultimately involve international co-operation.

(8) The question of *direct-reading physical photometers* was discussed at a recent meeting of the Society, and a number of fruitful investigations were suggested.

(9) The design of better and simpler *illumination photometers*. Instruments of the simpler class are probably best left to individual workers; but it would be useful to make an inquiry into the probable accuracy of the various kinds available, and to institute a series of comparative tests with various instruments by different observers in streets and interiors. The preparation of a *specification for illumination photometers* intended for tests in which contracts and legal penalties are involved might follow after the above experiments.

(b) Electric, Gas, and other Illuminants

(10) Experiments on *the improvement of lamps* are naturally undertaken mainly by manufacturers, but questions of scientific interest arise, the elucidation of which would be of value in establishing the principles governing the efficiency of illuminants. In many such cases the immediate commercial return may not be sufficient to induce individual manufacturers to make experiments, but there is scope for the prosecution of such inquiries in the laboratories of technical and scientific institutions, and the Society would gladly welcome co-operation on the part of the manufacturers and suggestions regarding experiments of this nature.

The time is ripe for promoting greater uniformity in methods of *testing and describing the illuminating value of lamps of various kinds*, and it would be advantageous if general agreement on this point could be obtained.

(c) Lighting Appliances (Globes, Shades, Reflectors, &c.).

The remarks made under the last heading also apply here.

The supply of *optical glass* and the investigation of its properties are at present of great national importance and the Committee would be glad to receive any suggestions for useful service in this direction.

As regards *glassware required in the lighting industry*, it is common knowledge that considerable inconvenience has been caused by the shortage of many kinds of glass hitherto imported and there appear to be opportunities for research in connection with the manufacture of these varieties of glass in this country.

It is accordingly suggested that a sub-committee should be appointed to consider—

(11) The best means of promoting the scientific study of *lighting glassware* and of encouraging the manufacture of kinds of glass which have not hitherto been developed satisfactorily in the British Isles. Amongst such varieties may be mentioned suitable heat-resisting glass for use in chimneys, globes, &c., used with high temperature illuminants; white diffusing glassware having suitable qualities as regards minimum absorption of light, uniformity of structure and diffusion of light; neutral tinted glass of specified absorbing value required for optical and photometric work; and special varieties of coloured glassware used for the production of "artificial daylight."

(12) Appropriate methods of *testing and prescribing the requisite qualities of glassware* of the above kinds.

(13) *Uniformity of method in testing and specifying the distribution of light, absorption* and other qualities of globes and reflectors of importance from the illuminating engineering standpoint.

(14) The best means of promoting agreement as to *uniform sizes and shapes of glass articles in common use in the lighting industry*, in cases where such uniformity is desirable in the interests of manufacturers and the public.

In connection with these researches the co-operation of other bodies interested in the study of glassware would no doubt be desirable.

(d) General.

Among other suggestions may be noted:—

(15) Research work on an instrument for the *automatic control of artificial light in factories, schools, &c.*, the light being automatically turned on when the

illumination has fallen to a certain value. This is a problem more hopeful of immediate solution than the design of a direct reading physical photometer, and there are already several suggested forms of apparatus which deserve comparison and study.

(16) As a development of the Home Office Report on Factory Lighting it would be helpful to make further unofficial investigations on the *conditions desirable for various classes of work*, and subsequently to issue these as a brief series of recommendations for the guidance of managers and others interested in factory lighting.

(17) A good deal remains to be done in further prosecution of the work of the *Daylight Illumination in Schools*. The Joint Committee appointed by the Society in 1913 reported shortly before the outbreak of war and made a number of suggestions for future work.* At that time there appeared no immediate prospect of securing the assistance requisite to carry these investigations to completion, but it is hoped to proceed with them when opportunity offers.

(18) *Street lighting*, after the war, will be a good field for effort, particularly as regards the development of more decorative forms of design as well as more scientific treatment in respect of the shading of lamps and the distribution of light. The war has impressed people with the importance of street lighting, and the conception of a minimum illumination desirable in the interests of safety should be encouraged.

As regards the design of lanterns placed outside public buildings work might be done in co-operation with Arts and Crafts Associations and the London Society. It might at least be possible to form clearer ideas during the war as to what could be accomplished afterwards.

(19) *Searchlights*. There are many questions of interest, but their full consideration at the present time would require the co-operation of the military and naval authorities. At the meeting in February, 1915, it was suggested that experiments might be made on the following points :—

Possible improvements in efficiency (as for example those involved in the new searchlight evolved by O. Lummer of Breslau).

Investigations into the various points suggested by Mrs. Ayrton in connection with the choice of carbons, best electrical conditions, &c. ; also into the type of electrical generator best adapted for searchlights.

Preparation of simple instructions for working searchlights.

Attempt to define more precisely the "range" and the "candlepower" with a view to these quantities being specified in the future.

Inquiry into the best colour of light, as regards its effect on penetrating power and on the apparent sharpness of object illuminated by the searchlight beam.

(20) *Visibility*. A series of queries was put forward in connection with the paper on this subject by Messrs. Paterson and Dudding (*Illum. Eng.*, May, 1915, p. 208). Many of these, such as the relative visibility by natural and artificial light, by direct and indirect light, &c., require study.

The question is of military interest in connection with concealing operations from the enemy, rendering uniforms, aeroplanes and ships difficult to see, and possibly in the future some investigation would be considered by the War Office or Admiralty.

(21) *Lighting of Rifle Ranges*. The series of queries prepared in this connection has not been completely answered.* It was proposed to form a Committee to deal with the matter, but so far it has been difficult to find members who were free to undertake such experiments.

(22) An inquiry is suggested into the *Physiological difference between Natural and Artificial Light, e.g.*, the intensities considered necessary for vision.

(23) Investigation of the conditions determining *permissible limits of intrinsic brilliancy* ("Glare"). A suggestive Report on this subject has been issued by a Committee in the United States, which merits discussion.

(24) The problem of devising some means of judging *the comparative effect on the eyes of various methods of lighting, as regards fatigue, comfort of vision, &c.*

* *Illum. Eng.* July, 1914, p. 365.

* *Illum. Eng.*, June. 1915, p. 250.

An attempt in this direction has been made in the States, but little has been done in this country.

(25) *Library Lighting.* Various points remain for consideration from the discussion and subsequent report of the Committee in 1911. The lighting of racks and shelves is still regarded as a somewhat difficult problem.

(26) *Lighting of Museums and Picture Galleries.* It was proposed to form a Committee to study this subject previous to the war, after the discussion initiated by Professor Thompson in 1914. Among the points for consideration are the general arrangements of natural and artificial lighting to illuminate pictures and exhibited objects in showcases; the possibility of employing a method of illumination resembling daylight in colour; the desirability of special local lighting for certain pictures, objects in showcases, &c.

(27) *Lighting of Hospitals.* The lighting of hospital wards is admittedly often unsatisfactory. There is also room for investigation in the lighting of operating tables. The subject might also be studied in connection with field hospitals using portable illuminants, &c.

(28) *Testing the gloss of paper,* and the determination of a *standard of matness.* This matter has been carried to a certain stage by Mr. Trotter's experiments and the inquiry of the Committee of the British Association (*Illum. Eng.*, October, 1915, p. 425), but the subject still requires investigation.

(29) *Nomenclature of illuminating engineering.* The subject was left in a state of suspension before the war, and requires international treatment.

(30) Tests of the effect of varying *the reflecting power of walls, ceilings and floors in rooms,* with a view to preparing data by the aid of which the increased illumination due to reflected light may be more precisely estimated. The effect of varying these conditions on the shadows and diffusion of light also deserves inquiry.

TENTH ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY, U.S.A.

THE Tenth Annual Convention of the American Illuminating Engineering Society will be held in Philadelphia, September 18th, 19th, and 20th, 1916.

Immediately following the Convention there will be given at the University of Pennsylvania under the joint auspices of the University and the Society, a course of twenty lectures on the theoretical and practical aspects of Illuminating Engineering.

The lectures will be delivered by eminent authorities in the lighting world, and will occupy approximately eight days.

Further particulars of this course of lectures will be issued later.

TENTH ANNUAL MEETING OF THE BRITISH SCIENCE GUILD.

THE Tenth Annual Meeting of the British Science Guild took place in the rooms of the Royal Society of Medicine (Wimpole Street, London) at 4 p.m. on Wednesday, May 17th, the chair being taken by the President, the Rt. Hon. Sir William Mather.

The usual Annual Report was presented. It contains a very serviceable summary of the chief events in the scientific world during the past year, reference being made to the work of the Advisory Council to the Committee of the Privy Council on Scientific and Industrial Research, the proposal of the Royal Society to form a Conjoint Board of Scientific Societies, and other important matters. A feature is the Appendix, by Prof. R. A. Gregory, on "The Promotion of Scientific Research and Higher Education."

In the course of the meeting an address was given by the Rt. Hon. Andrew Fisher, who explained the proposed establishment of a National Institute of Science and Industry in Australia. Among others who spoke, Dr. R. Mullineux Walmsley referred to the need for a National School of Technical Optics, and Sir Alfred Keogh gave a brief account of the application of science in the work of the R.A.M.S., instancing the marvellous success attained in the prevention of typhoid fever.

REVIEW OF BOOK.

Newsholme's "School Hygiene; the Laws of Health in relation to School Life," by James Kerr, M.A., M.D. (Geo. Allen and Unwin, Ltd., London. 1916. pp. 352; illustrations, 49.)

NEWSHOLME'S "School Hygiene" was first published in 1887, and attained its twelfth edition in 1907. The book has now been re-written and brought up to date by Dr. James Kerr, whose name will be familiar to readers as one who has taken a deep interest in the scientific lighting of schools, and who participated in the work of the Joint Committee of the Illuminating Engineering Society dealing with this subject.

The early portion of the book is devoted to physiology, psychology, and ethics in relation to hygiene. The nature of the organs of speech, sight, and hearing, and the centres of perception are explained, and the author then passes on to show the bearing of this information on school life. Some questions of wide general interest are discussed: for example, the value of open-air schools in combatting consumption; the care of abnormal and physically defective children; nutrition, physical education and medical inspection. A specially interesting chapter deals with mental and physical fatigue. Apparently there are now quite a variety of methods of testing fatigue, some of which have already proved of value in the study of industrial hygiene. There are also practical suggestions on clothing and cleanliness and the organisation of first aid in case of accidents. Some diagrams are presented showing the tendency towards deterioration of vision during school life, and the author refers to several defects in lighting which are apt to accentuate these conditions. Special importance is attached to the use of good white paper in school books, and type of suitable size.

Part II., dealing with apparatus, contains several chapters on ventilation and heating, of which the author has made a special study. After considering the selection of a suitable site for a school, we come to the design of the class-room, where heating, lighting, and ventilation must often be considered conjointly. The selection of suitable school furniture also merits attention. We are glad to see that a special chapter has been devoted to illumination—a matter which has sometimes been overlooked in works on school hygiene. Dr. Kerr discusses the fundamental principles of good lighting, such as the proper position and area of windows, the direction of artificial light and the avoidance of glare, in connection with which he quotes from the recommendations of the Joint Committee of the Illuminating Engineering Society.

The ideas of the author are expressed in simple language and the pages are illustrated by many useful diagrams. Apart from its evident value to school medical officers and educational authorities, the book will be read with interest by many who have little technical knowledge of the subject treated.

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To whom Notice of Claims under the following conditions must be sent within seven days of accident.

£250 TWO HUNDRED AND FIFTY POUNDS will be paid by the above Corporation to the legal personal representatives of any person who is killed by an accident causing material damage to the passenger train in which the deceased was travelling as a ticket bearing or paying passenger, or who shall have been fatally injured thereby, should death result within one calendar month after such accident. **Provided** that the person so killed or injured had upon his or her person, or had left at home this coupon, with his or her usual signature, written prior to the accident, in the space provided below, which, together with the giving of notice within seven days to the above Corporation is the essence of this contract.

This Insurance only applies to persons over 14 and under 65 years of age, is subject to the conditions stated above and contained in the General Accident Fire and Life Assurance Corporation Act, 1907, and holds good for the current month of issue only.

No person can recover under more than one Coupon Ticket in respect of the same risk.

Signature .....

This Coupon must not be cut out, but left intact in THE ILLUMINATING ENGINEER as that being dated, forms the only evidence of its currency.

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THE LATE SIR CORBET WOODALL.

READERS of the Journal will have learnt with a lively regret, shared by all who ever came in contact with him, of the death of Sir Corbet Woodall, J.P., D.Sc., M.Inst.C.E., Governor of the Gas Light and Coke Company and the leading consultant in the world of gas engineering, which took place rather suddenly on May 17th at Torquay, whither his doctors had ordered him for a short spell of rest and recuperation. For some time past his health had not been satisfactory, owing largely to the fact that his mental energy, like his appearance, belied his 75 years, and tempted him to work himself to a degree of which his bodily powers could no longer stand the strain.

One could almost wish him to have fallen where he stood in the works or offices of the Gas Light and Coke Company, for if ever anyone lived, moved, and had his being in the work of his choice, Sir Corbet was that man; and his employees knew him to be not in name alone but in very truth the Governor of that great Company with which he was so intimately associated. They will long remember him as an engineer who "knew his job" down to the smallest detail; as a master who demanded the best of which those who served him were capable, but was equally unsparing of himself; as a man no less ready with encouragement and sympathy where such were needed than with criticism and reproof where such were deserved.

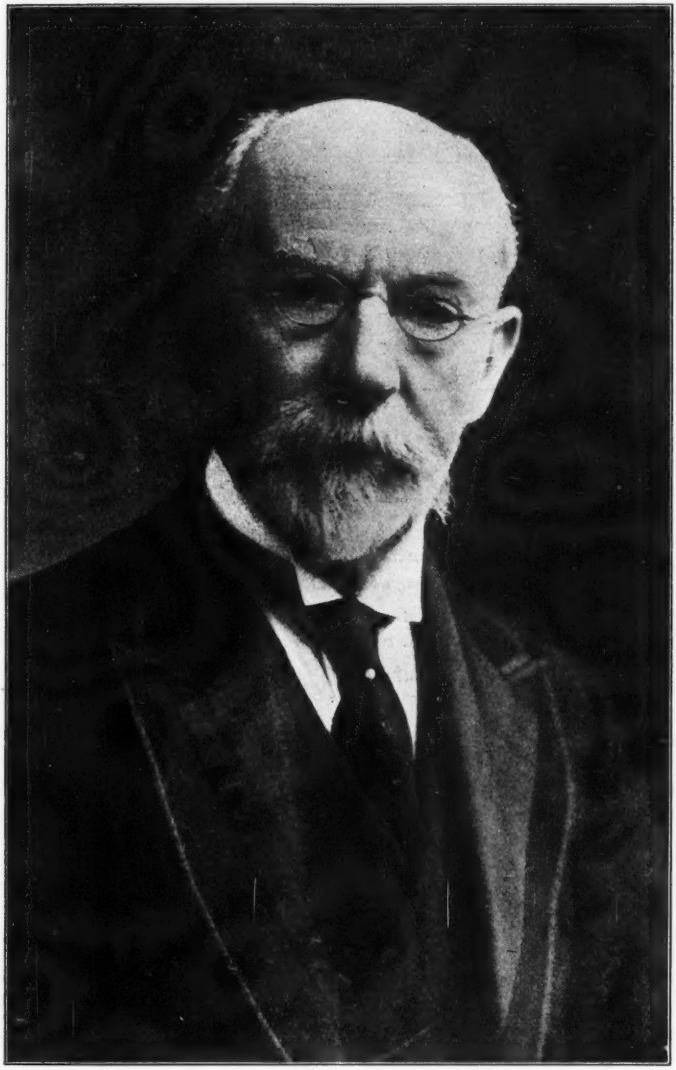
Sir Corbet Woodall became Governor of the Gas Light and Coke Company in the year 1906, and for several years previously had been the moving spirit on the Board. One of the earliest services he rendered to the Company was to initiate the establishment of good relations between it and its consumers by the organisation of a sales department founded on the principle of mutual benefit; and it was not long before the soundness of this policy was amply vindicated. His genius for administration found further scope in the well-known "co-partnership" and "apprenticeship" schemes of the Company, in both of which undertakings he was a prime mover. Under the former of these schemes substantial bonuses reward faithful service, without prejudice to rates of pay and hours of labour; by the latter, boys who have just left school undergo six years' free training in gas fitting in the Company's workshops together with a specially-arranged continuation course at the L.C.C. Westminster Technical Institute. The success of this arrangement was an abiding joy to Sir Corbet, whose sympathy and support could always be enlisted for educational clubs for boys and other such undertakings.

Of the world-wide engineering reputation of "the veteran head of the gas industry," as he has been termed with admiring affection, there is little need to speak here. Suffice it to recall that he was knighted by King George on January 1st, 1913, immediately following the year of the centenary of gas lighting (1912), when he held simultaneously the three offices of President of the Institution of Gas Engineers, President of the Society of British Gas Industries, and President of the British Commercial Gas Association, as well as that of President of the National Congress and Exhibition in which all three organisations joined. In that same year, moreover, his research and other scientific work won him the honorary degree of Doctor of Science of Leeds University. For our own Society, of which he was an honorary member, he had warm sympathy, though the pressure of his many other engagements and the strict orders of his doctor rendered it impossible for him to be a frequent visitor at our meetings.

Chief, perhaps, of all the many ways in which he served his country after the outbreak of war was the part he played in bringing about the successful development of engineering methods which enabled the gas undertakings of the Kingdom to meet the demands made on them by the Ministry of Munitions for an adequate supply of materials for high explosives. His death is a real loss to the country, as well as to the whole engineering world, and in particular the gas industry: for

"He was a man: take him for all in all,
We shall not look upon his like again."

F. W. GOODENOUGH.



By the courtesy of the "Journal of Gaslighting."

SIR CORBET WOODALL,

GOVERNOR OF THE GAS LIGHT AND COKE COMPANY.

BORN AUGUST 27, 1841. DIED MAY 17, 1916.

SCIENCE IN EDUCATION AND EXAMINATIONS.

A meeting called by the Committee on Neglect of Science, took place at Burlington House on May 3rd.

Lord Rayleigh, who presided, remarked that the ignorance of natural science among all classes was deplorable, and urged that in educational institutions more attention should be given to this subject, and also to modern languages. Sir Ray Lankester spoke to the same effect, and the following resolution was then moved by Sir E. Schäfer, and supported by Dr. Bridges, Lord Montagu, Col. Crompton, Lord Portsmouth, Mr. H. G. Wells, and other speakers :—

"That in the opinion of this meeting it is a matter of urgency, in order to promote national efficiency in the near future, that the natural sciences should be made an integral part of the educational course in all the great schools of this country, and should form part of the entrance examination of the universities of Oxford and Cambridge, as well as of the newer universities."

Another resolution was moved by Sir H. Johnston :—

"That it is in the highest degree desirable that the Government should exercise the large power it possesses of encouraging the study of the natural sciences, and thereby increasing the efficiency of our public servants : (1) by assigning capital importance to the natural sciences in the competitive examinations for the Home, Indian, Foreign, and Colonial Civil Service ; 2) by requiring some knowledge of the natural sciences from all candidates for admission to Sandhurst."

This resolution received the support of Prof. Poulton, Prof. Turner, and Mr. Nowell Smith of Sherborne, and was likewise adopted.

ORGANISED SCIENCE.

A conference, at which many of the chief technical and scientific societies were represented, was called by the President and Council of the Royal Society on March 22nd, when the following resolution was passed unanimously :—

"This meeting considers that it is desirable to establish a Conjoint Board of Scientific Societies for the purpose of :—

"(1) Promoting the co-operation of those interested in pure or applied science ;

"(2) Supplying a means by which the scientific opinion of the country may, on matters relating to science, industry and education, find effective expression ;

"(3) Taking such action as may be necessary to promote the application of science to our industries and to the service of the nation ;

"(4) Discussing scientific questions in which international co-operation seems advisable."

A Committee has been appointed to consider the best means of giving effect to this resolution.

ECONOMY IN LIGHTING.

A circular issued by the Board of Trade draws attention to the need for economy in the use of fuel at the present time, in order to enable the export trade to our Allies and neutrals to be maintained.

With a view to promoting economies in this direction, the Central Coal and Coke Supplies Committee have recommended that a general policy of economy in lighting should be adopted. Gas and Electric Lighting undertakings are accordingly asked to notify to consumers the Government's desire that the consumption of coal for lighting purposes should be reduced by 10 per cent.

(We propose to deal more fully with this matter in our next number.—ED.)